Layer Precipitable Water (LPW) Briefing

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In preparation for Intensive Evaluation

Period July 15 – Sept 15

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Cooperative Institute for Research in the Atmosphere

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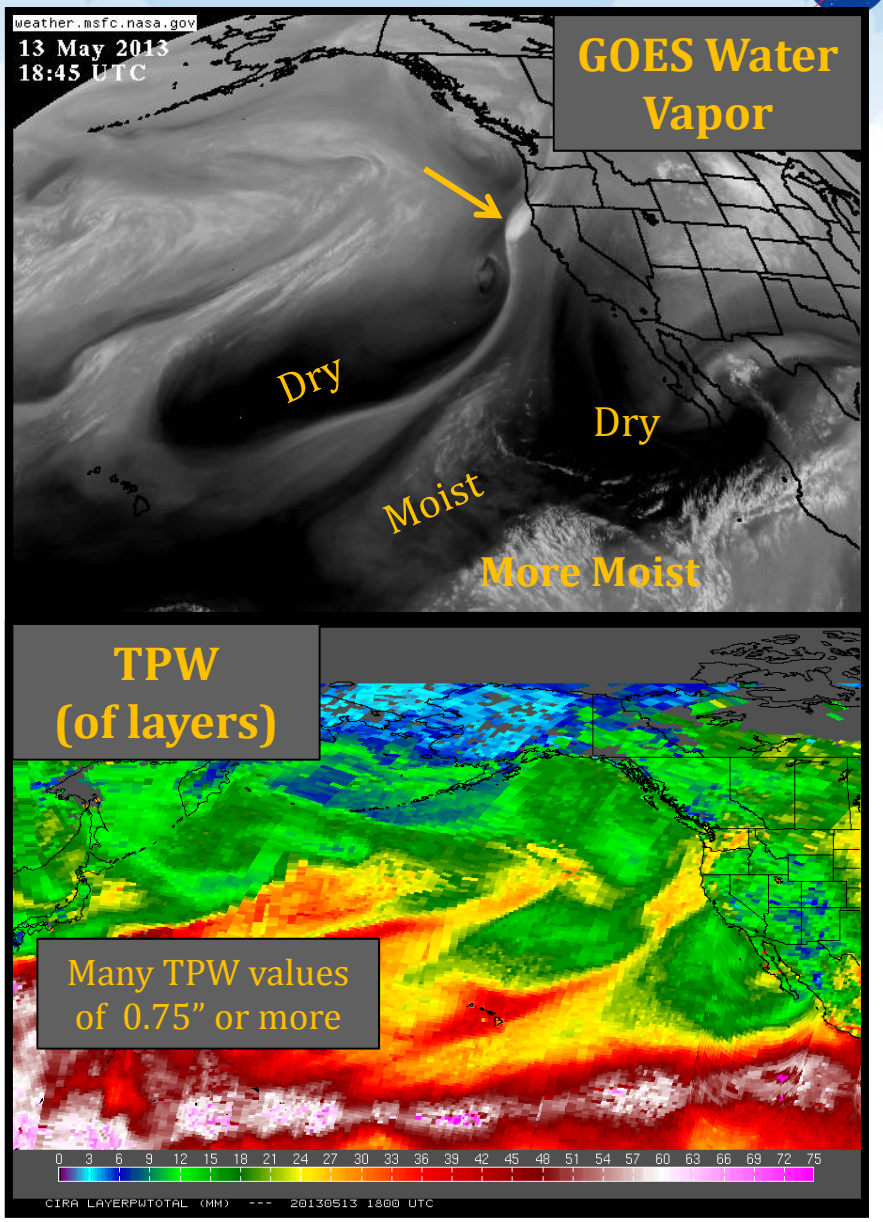
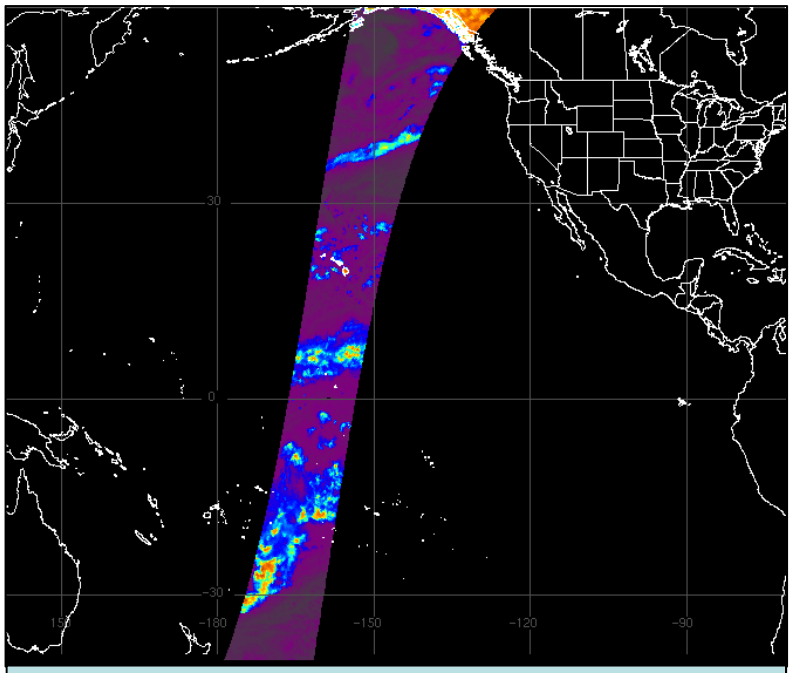
Why have Layered PW?

- WV imagery only senses upper level moisture
- WV imagery senses higher in moist regions and lower in dry regions *(first 1-2mm in cloud free regions, Jedlovec et. al. 2000)*
- TPW has no vertical moisture distribution information
- Note how WV and 500-300mb layer PW match well
- WV is only small portion of TPW as most moisture is near lower boundary layer



Microwave Integrated Retrieval System - MIRS

- Retrieves many variables from microwave sounding instruments (Boukabara et al. 2011)
  - AMSU-A, MHS, SSMI/S
- Uses 1DVAR (e.g., Rodgers 2000) retrieval scheme to retrieve atmospheric profile plus surface conditions.
- Retrievals through clouds
- Over water and land!
- Operationally produced by NOAA / NESDIS



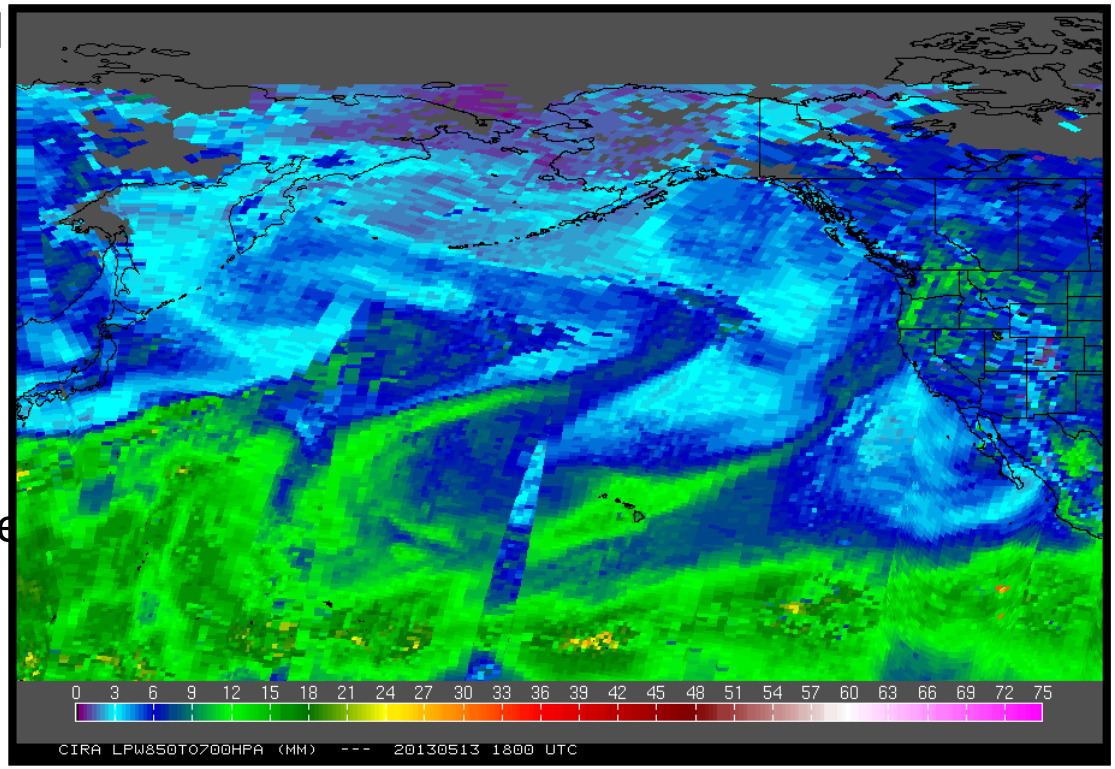
37GHz (H) Brightness Temperatures from SSMI/S instrument on DMSP satellite. Just one example of the channels used by MIRS

Layer Precipitable Water (LPW)

- MIRS mixing ratios (q) integrated to yield Layer Precipitable Water:

$$LPW \equiv \int_{p_{top}}^{p_{bottom}} q \frac{dp}{g}$$

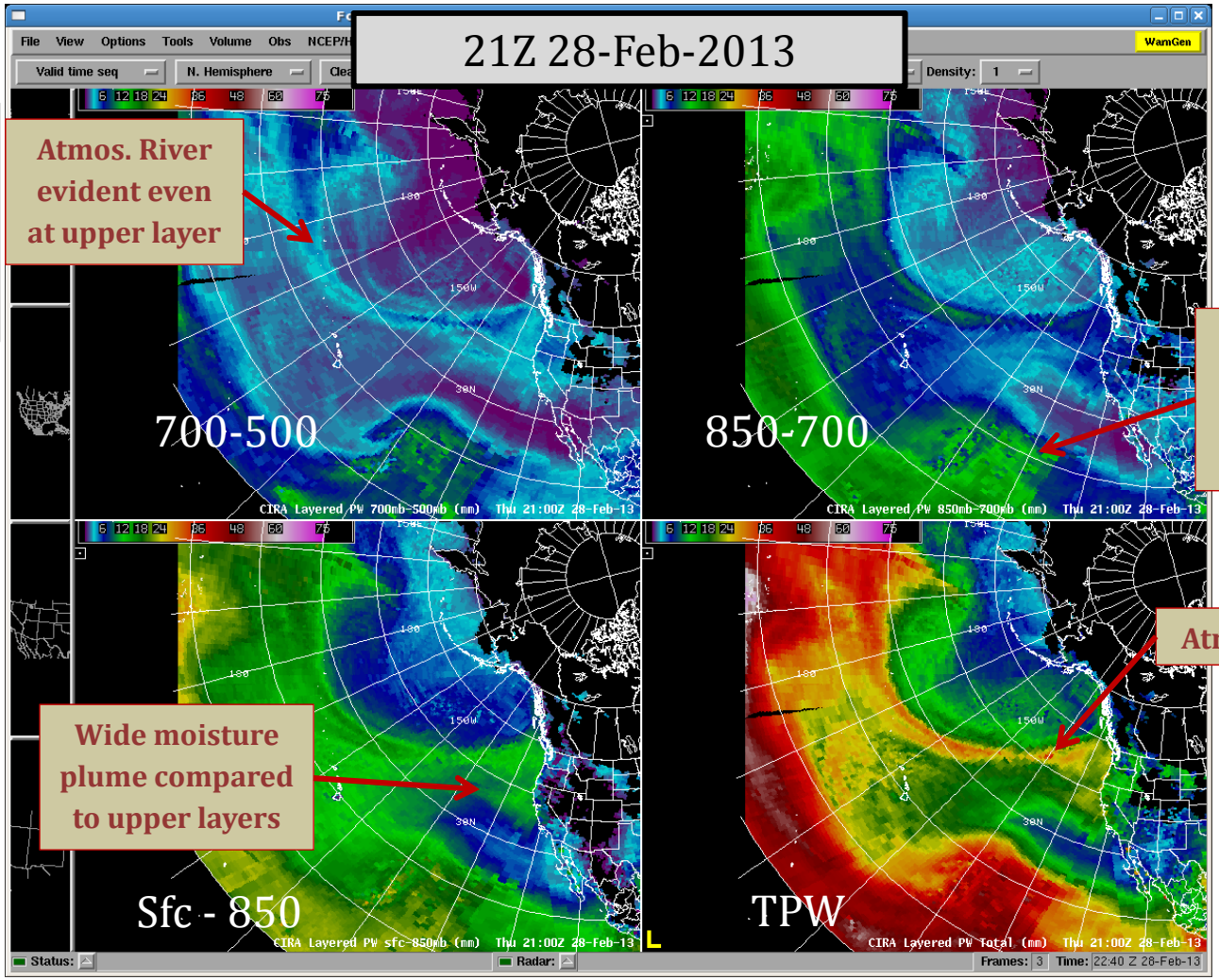
- *When p_{bottom} is at the surface (p_{sfc})* it is a function of surface elevation only; it does not change with changing weather conditions.
- If p_{sfc} is less than 850 hPa but greater than 700 hPa, then the bottom layer is missing (black) and the 850 to 700 hPa layer is calculated from p_{sfc} to 700 hPa.



850mb-700mb LPW over Pacific and western North America regions derived from MIRS

Chosen Layers of LPW – in D2d

NOTE: 500-300 hPa layer not shown



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Satellite Local Time Passes

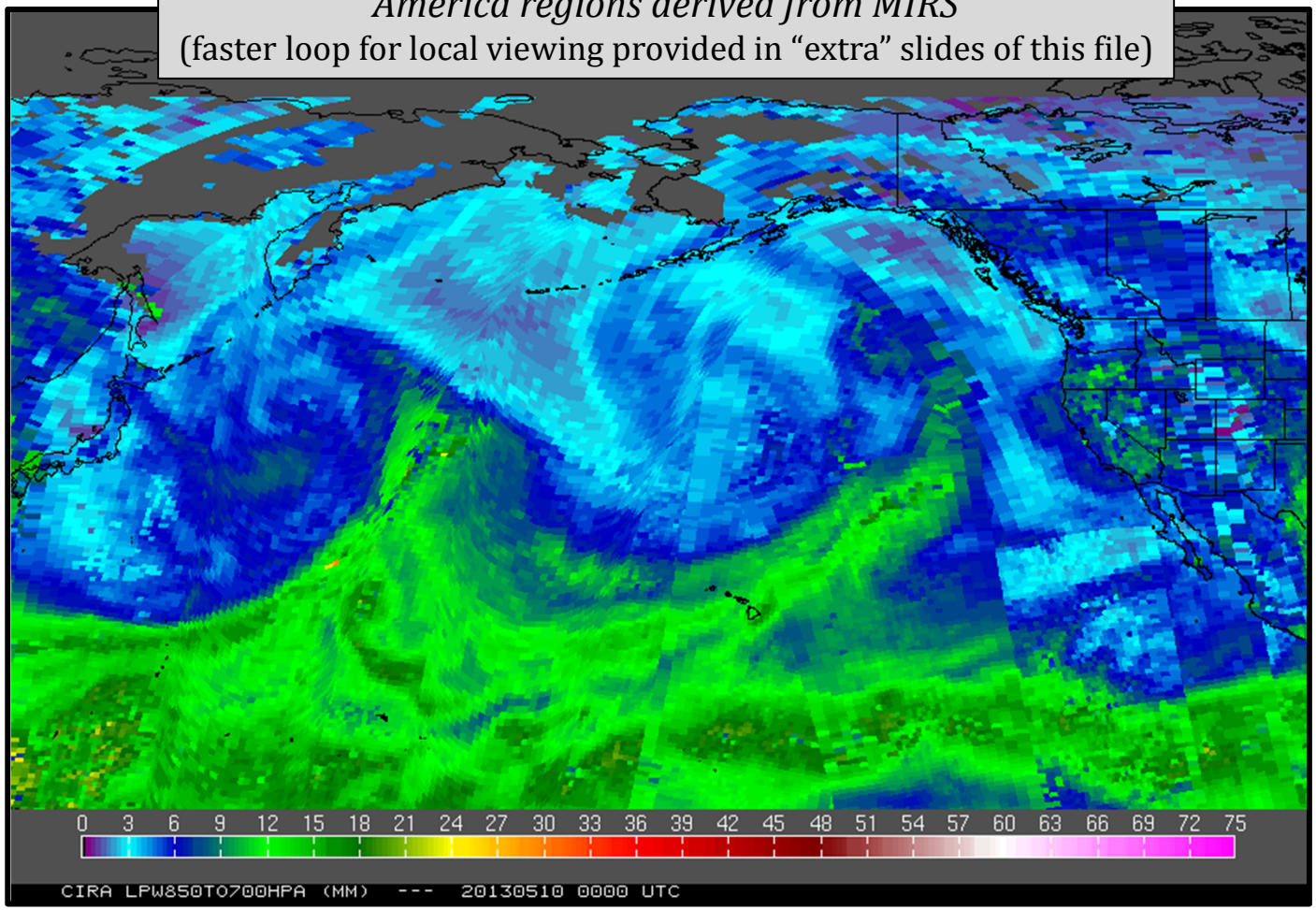
Satellite (Instrument)	Approx. Local Time Ascending	Approx. Local Time Descending
NOAA 18 (AMSU-A, MHS)	1500	0300
NOAA 19 (AMSU-A, MHS)	1330	0130
Metop-A/B (AMSU-A, MHS)	2130	0930
DMSP F18 (SSMI/S)	2000	0800
NASA Aqua (AIRS, *infrared*)	1330	0130

Notes

1. The actual observation time is within about ½ orbit (50 min) of the above times.
2. AIRS retrievals only in clear or thin cloud areas

850-700 mb LPW Loop – May 10, 2013

850mb-700mb LPW over Pacific and western North America regions derived from MIRS
(faster loop for local viewing provided in "extra" slides of this file)



When is LPW available and How is LPW Composited?

- Program runs every 3 hours at 00Z, 03Z, ….
  - Data latency to user is ~40 minutes (i.e. 1800Z arrives at 1840Z)
- Data for the last 12 hours are plotted with the newest observation on top (covering up older observations)
  - No averaging or smoothing of data
- There is a 1-2 hour gap between the time on the image and the latest satellite data due to the time it takes to transmit the data to the ground, do the retrievals, and make the composites.

LPW Strengths

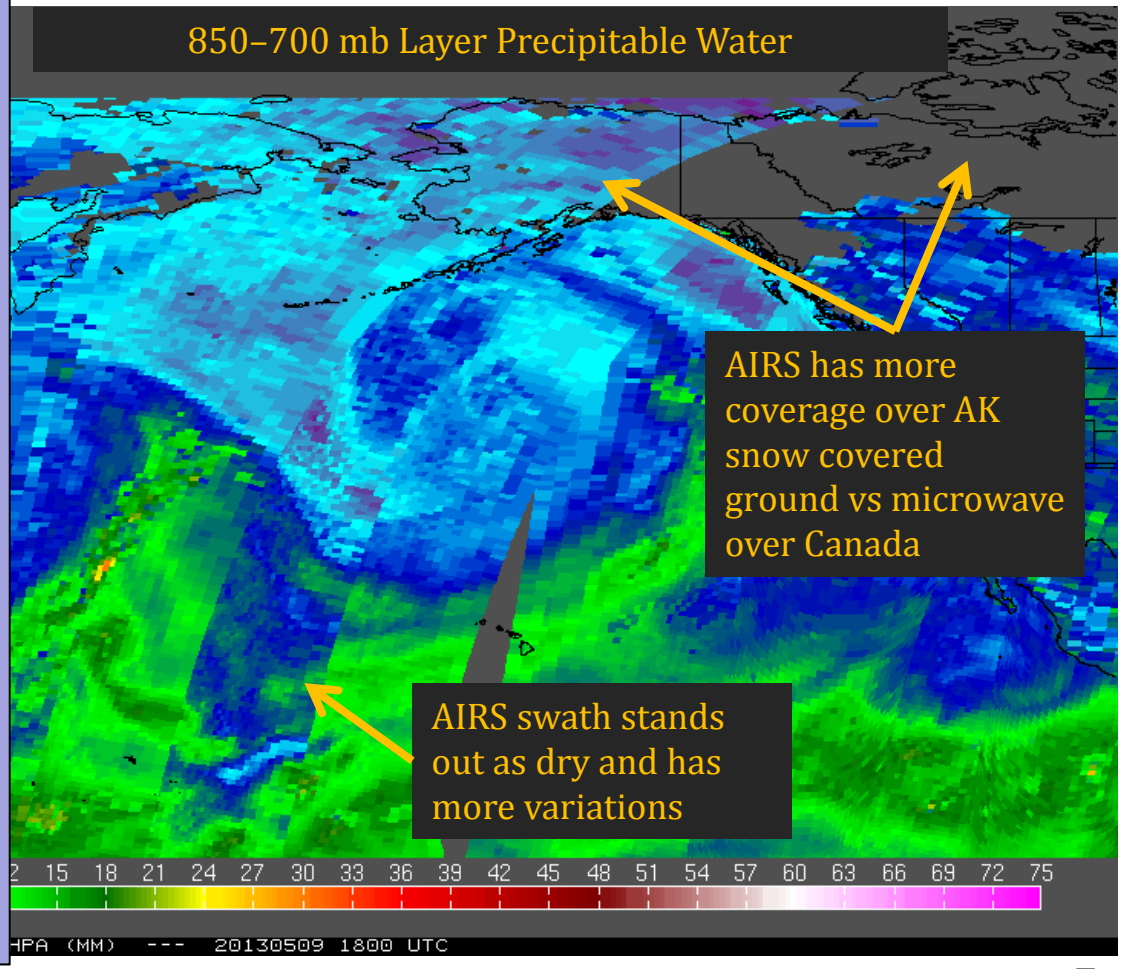
Strengths

- Vertical resolution to diagnose moisture distribution vs TPW whole column approach
- Sounding coverage over data-sparse oceans several times per day
- Spatial detail well beyond radiosonde network
- Composite of many similar instruments
- Use of microwave data over land
- Microwave retrievals probe through clouds

LPW Weaknesses

Weaknesses

- Discontinuities can occur due to time or instrument differences
- Change in magnitude near land/ocean boundary possible
- Less vertical detail than RAOBs or profilers
- Satellite retrieval latency of 2-4 hours
- AIRS retrievals (infrared) are somewhat different than microwave retrievals
  - Higher resolution has more detail ("noisy" variation)
  - Dry bias compared to other microwave instruments
  - Can retrieve over snow (*Strength*)



LPW Applications

From WFO Area Forecast Discussions (AFD), these issues would benefit from LPW:

Verification of model short-term, vertical moisture distribution

- Portland, OR ...MODELS CONTINUE TO INDICATE MOST OF THE LOW LEVEL MOISTURE GETTING WRUNG OUT BY ….

Monitoring of upper level moisture advection for clouds and atmospheric rivers

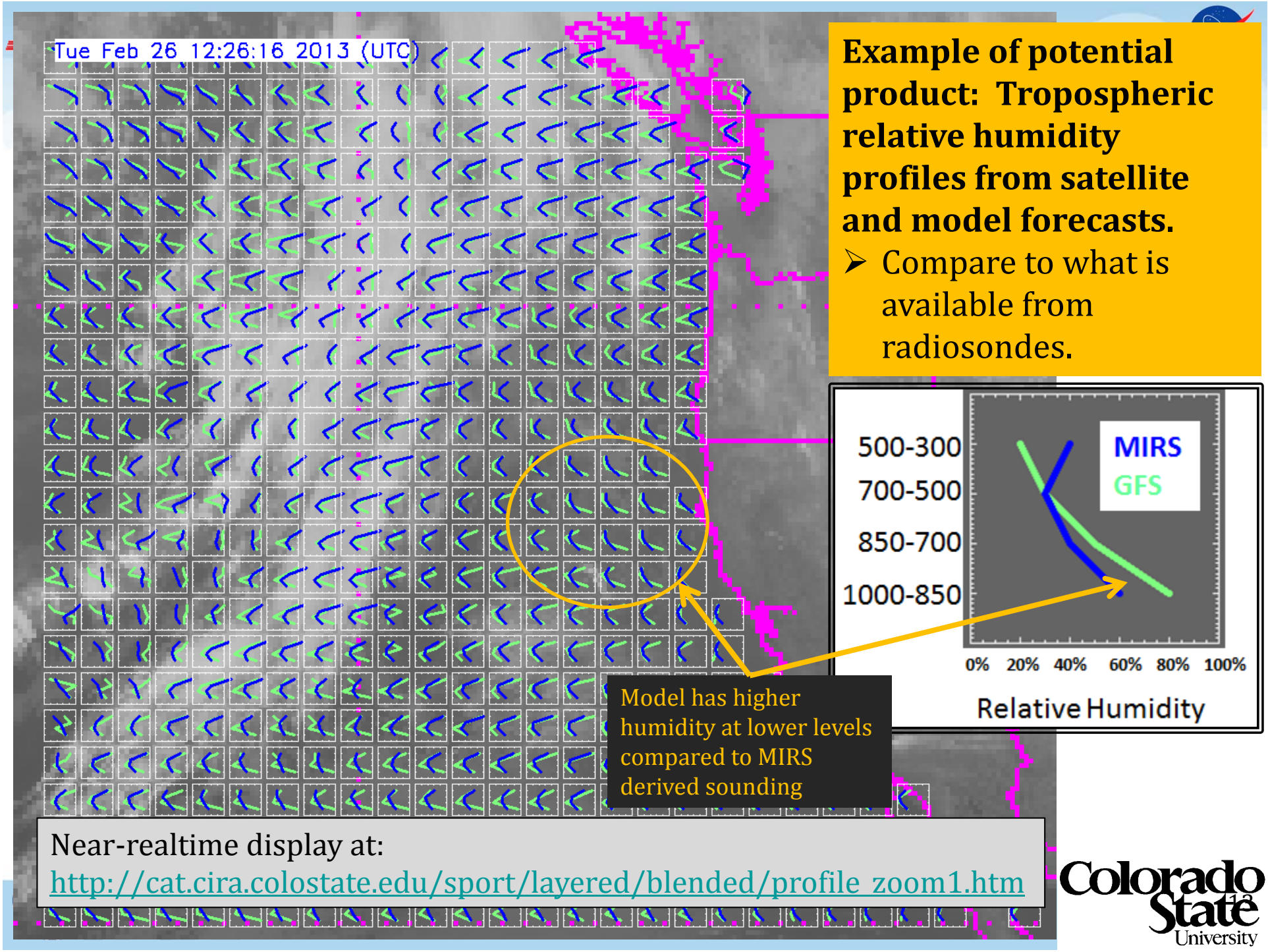
- Phoenix, AZ ...GIVEN THE BROAD SWLY FLOW AND LIKELIHOOD OF TAPPING EXTENSIVE UPPER LEVEL SUBTROPICAL MOISTURE ONCE AGAIN...HAVE GENERALLY NARROWED THE FORECAST DIURNAL RANGE...ESPECIALLY WITH RESPECT TO HIGHS
- Albuquerque, NM ...THE UPPER RIDGE FLATTENED-OUT OVERNIGHT AND WESTERLIES HAVE OVERTAKEN OUR AREA WITH PACIFIC MOISTURE ADVECTION IN THE MID AND UPPER LEVELS OF THE ATMOSPHERE RESULTING IN CLOUDS.

Analysis of 2-d moisture gradients aloft verses relying on point source data

- San Diego, CA … THE 00Z MIRAMAR SOUNDING SHOWED A PW JUMP TO JUST OVER ONE-HALF INCH. THE MOIST LAYER WAS BETWEEN 8K AND 13K FT.

What Needs to be Evaluated in Operations

- Which forecasting problems benefit most from having LPW information and how
- How much the LPW information helps the forecast over having only TPW and GOES 6.7 μm data in operations
- Ways to make the products more operationally useful, for example by selecting different layers, calculating different variables (e.g., RH), or comparing with climatology (e.g., percent of normal).


Tue Feb 26 12:26:16 2013 (UTC)
Example of potential product: Tropospheric relative humidity profiles from satellite and model forecasts.
➢ Compare to what is available from radiosondes.
500-300
700-500
850-700
1000-850
MIRS
GFS
0%
20%
40%
60%
80%
100%
Relative Humidity
Model has higher humidity at lower levels compared to MIRS derived sounding
Near-realtime display at:
http://cat.cira.colostate.edu/sport/layered/blended/profile_zoom1.htm
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LPW Summary

- Microwave Integrated Retrieval System (MIRS) provides soundings of specific humidity from a variety of instruments and is combined with AIRS infrared soundings to create a Layered Precipitable Water (LPW) composite product
- The LPW provides vertical moisture information in the column instead of just upper levels via WV imagery, or a single column value via TPW products
- LPW is created every 3 hours using the last 12 hours worth of data and has a delivery latency of 40 minutes.
- Weaknesses include discontinuities in the composite
- Strengths include seeing through clouds, over land usage, and greater spatial coverage of vertical moisture profiles
- Applications of LPW include analysis of horizontal and vertical moisture gradients, verification of NWP moisture, and analysis of atmospheric rivers and other moisture advection.
- Operational testbed is ongoing to determine viability of wider distribution

References

Boukabara, S.-A., et al., 2011: MiRS: An All-Weather 1DVAR Satellite Data Assimilation and Retrieval System. *IEEE Trans. Geosci. Remote Sens.*, **49**, 3249-3272.

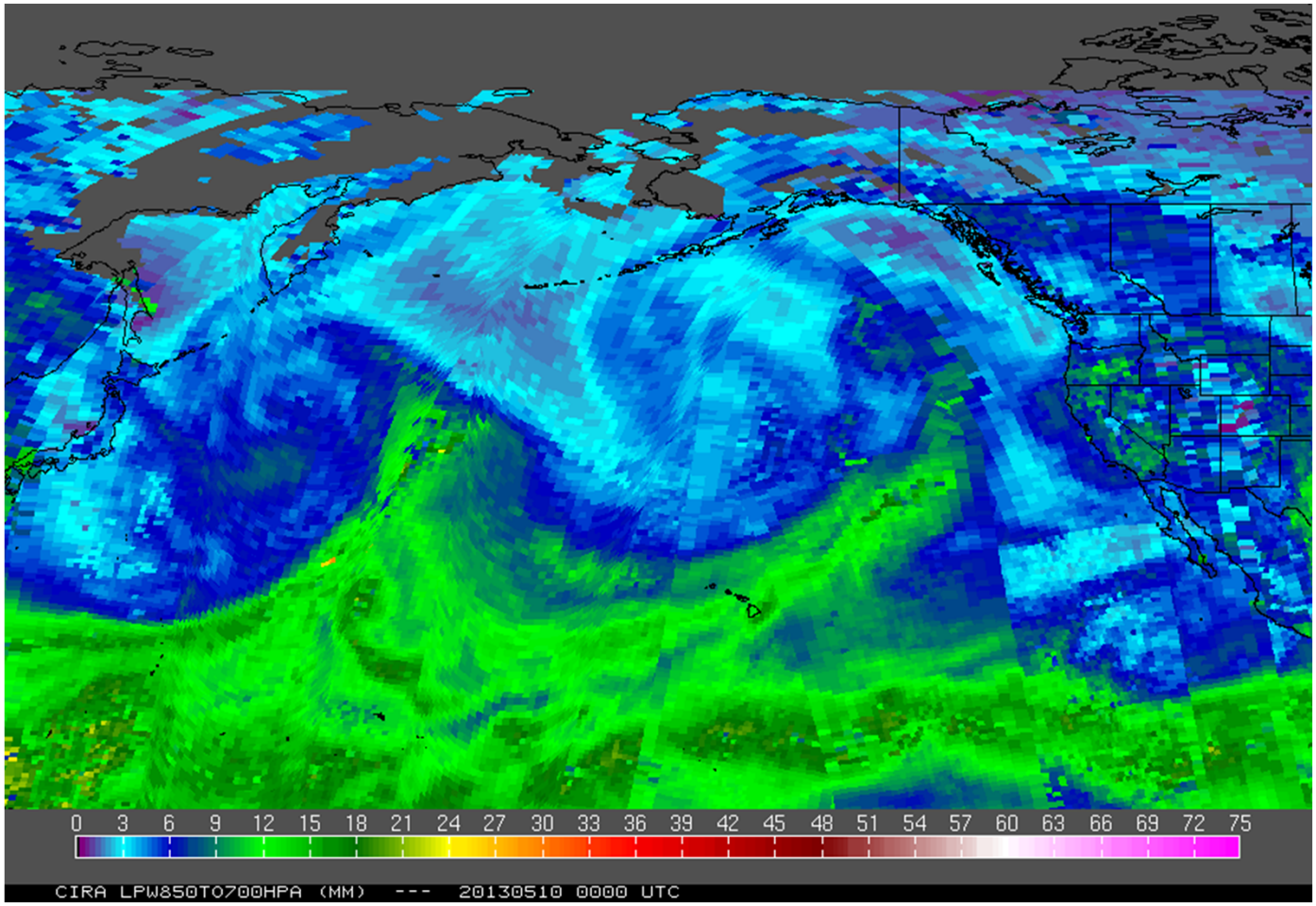
Rogers, C. D., 2000: *Inverse Methods for Atmospheric Sounding: Theory and Practice.* World Scientific, Singapore, 238 pp.

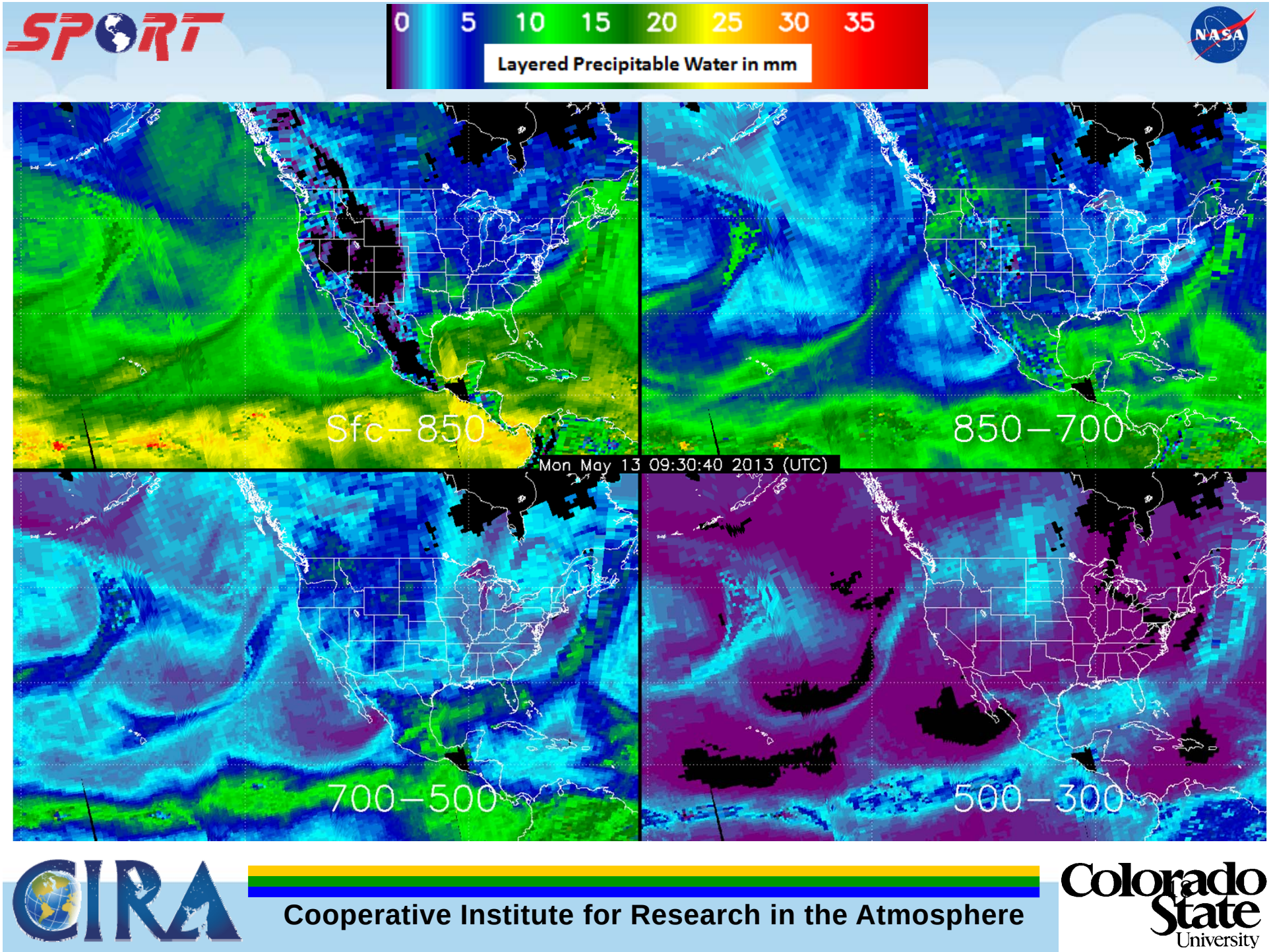
Jedlovec, G. J., 2000: A satelliite-derived Upper-Tropospheric Water Vapor Transport Index for Climate Studies. J. Appl. Meteor., **39**, 15-41

Faster loop from main slides, 4-panel loop of LPW layers

EXTRA SLIDES AFTER THIS POINT

Faster loop from slide #7




SPORT
0 5 10 15 20 25 30 35
Layered Precipitable Water in mm
NASA
Sfc–850
850–700
Mon May 13 09:30:40 2013 (UTC)
700–500
500–300
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